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Relationship Between Operator Experience and In Vitro Microleakage of Different Composite Materials in Class II Restorations#

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Research Article

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ABSTRACT

Objectives: To evaluate the influence of operator experience on microleakage in class II restorations performing by different restorative materials.
Material and Method: Two cavities of 4x4x3mm dimensions were carried out on the mesial and distal surfaces of 20 molar teeth by one operator. The teeth were randomly assigned to two groups according to the operator's skill: student group and expert group. It was divided into subgroups as specialist bulk-fill composite: Group 1A, student bulk-fill composite: Group 2A, specialist micro-hybrid composite: Group 1B, student micro-hybrid composite: Group 2B, Prime bond nt, a total-etch adhesive system, is used in all restorations. Each operator restored the mesial cavities with the bulk technique using a bulk-fill composite (Tetric-N-Ceram-Bulk) and the distal cavities with the layering technique using a micro-hybrid composite (Filtek Z250, 3M ESPE). After 24 hour of water storage and thermocycling the marginal microleage was evaluted using dye penetration technique and data were analyzed.
Results: When the restorative materials were evaluated without considering the operator, no statistically significant difference was found between them. When the scores of the operators were evaluated without considering the restorative materials used, no statistically significant difference was found between them. When the occlusal and gingival leakage scores of Group 2A were evaluated, more gingival leakage was observed than occlusal. There was no statistically significant difference between the in-group occlusal and gingival leak scores of the other groups.
Conclusion: There was no difference between the expert and the student in terms of microleakage values.

Keywords: Bulk-Fill, Microleakage, Operator Experience, Micro Hybrid Composite Resin, Total-Etch Adhesive.

Sınıf II Restorasyonlarda Operator Becerisi ve Farklı Restoratif Materyallerin Mikrosızıntıya Etkisi#

Bilgi
#Bu çalışma 23-25 Kasım 2021 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 1. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.
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ÖZ

Amaç: Farklı deneyim düzeylerine sahip uygulayıcıların, farklı restoratif materyaller kullanarak yaptıkları kompozit restorasyonların mikrosızıntı değerlerinin karşılaştırılmasıdır.
Yöntem: Çalışmada 20 çekilmiş dişin mezial ve distal yüzeylerine (tek operatör tarafından) 4x4x3mm boyutlarında kutu kaviteler hazırlandı. Dişler rastgele 2 gruba ayrıldı. Restorasyonlar 16 yıllık restoratif diş tedavisi uzmanı ve diş hekimliği 5.sınıf öğrencisi tarafından yapıldı. Her operatör dişin mesialini bulk-fill kompozit (Tetric-N-Ceram-Bulk) kullanarak bulk tekniğiyle distalini mikro-hibrit kompozit (Filtek Z250, 3M ESPE) kullanarak tabakalama tekniğiyle restore etti. Uzman hekim bulk-fill kompozit: Grup 1A, öğrenci bulk-fill kompozit: Grup 2A, uzman hekim mikro-hibrit kompozit: Grup 1B, öğrenci mikro-hibrit kompozit: Grup 2B olarak alt gruplara ayrıldı. Tüm restorasyonlarda total-etch adeziv sistem (prime bond NT) kullanıldı. Dişler distile suda 24 saat bekletildikten sonra termomekanik yükleme uygulandı. Mikrosızıntı testi için tüm örnekler %0,5'lik bazik fuksinde 24 saat oda ısısında bekletildi. Örnekler 10x40 büyütmede stereomikroskopla incelendi. Veriler Kruskall Wallis, Mann Whitney, Anova post hoc Tamhane ve Wilcoxon signed ranks testleri kullanılarak değerlendirildi.
Bulgular: Uygulayan operatör dikkate alınmadan restoratif materyaller değerlendirildiğinde ve kullanılan restoratif materyaller dikkate alınmadan restorasyonları uygulayan operatör skorları değerlendirildiğinde aralarında istatistiksel olarak anlamlı fark bulunmadı. Grup 2A'nın okluzal ve gingival sızıntı skorları değerlendirildiğinde gingivalde okluzale göre daha fazla sızıntı gözlenmiştir. Grup 1A, Grup 2B ve Grup 1B'nin oklüzal ve gingival değerleri arasında istatistiksel olarak anlamlı fark bulunmadı.
Sonuçlar: Mikrosızıntı değerleri açısında değerlendirildiğinde uzman ve diş hekimliği öğrencisi arasında fark bulunamamıştır.

Anahtar Kelimeler: Bulk-Fill, Mikrosızıntı, Operatör Deneyimi, Mikro Hibrit Kompozit Rezin, Total-Etch Adeziv.

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Introduction

Although composite resin has shown great advances since its invention, polymerization shrinkage remains a major cause of clinical failure.

Shrinkage stresses caused by polymerization shrinkage damage the connection between the cavity walls and the restoration, causing the formation of micro-cavities that allow the passage of saliva and oral fluids between the tooth and the restoration. As a result, discoloration, secondary caries, hypersensitivity and inflammatory changes may occur in the pulp tissue.

Researches has focused on improving placement techniques, materials, and the formulation of the composite, particularly the polymeric matrix of the material, to develop systems that reduce polymerization shrinkage stress.[1]

The incremental technique is the most widely used placement technique in direct restorations of composite resin. This technique improves the physical properties and marginal adaptability of composite resins by increasing light penetration and providing adequate polymerization.

In addition to these advantages of the incremental technique, there are disadvantages such as the presence of gaps between the composite layers, the inability of these layers to bond well, the risk of contamination and the long working time.[2]

Recently, composites called bulk-fill, which can be placed in a single move up to 4-6 mm thickness, have been developed in order to simplify and accelerate placement techniques. By decreasing the filler ratio of the bulk-fill composites, increasing the filler particle size and translucency, the depth of polymerization was increased, and polymerization shrinkage was reduced.

Restorations are under thermal and mechanical stress in the oral environment. These stresses can affect the results of microleakage that will occur between the tooth and the restorative material with different physical properties.

Operator experience can be as important as the material in the success of restorations. Although there are many studies on the effect of operators' level of experience on adhesive applications, there is not enough literature evaluating their effect on different composite resin applications.[3]

The aim of this in vitro study is to evaluate the effect of restorations made by operators with different levels of experience on microleakage using different restorative materials.

H_0: There is no difference between the microleakage values of restorations made by operators of different experience levels using different restorative materials.

Material and Methods

This study was approved by the Non-Interventional Ethics Committee of Istanbul Aydın University (File number:2019/91). All experimental stages of our study were carried out in Istanbul Aydın University Research Laboratory.

Sample preparation

Twenty caries-free, restoration-free, and crack-free human third molars extracted for periodontal or surgical reasons were used in this study. All calculus deposits and remaining connective tissue were removed by scaling with a hand instrumentation and the teeth were stored in 0.1% thymol solution, at +4 ^{o}C temperature, until the study was carried out.

Standard class II box cavities were prepared 1 mm above the CEJ on the mesial and distal surfaces of the teeth under water cooling with fissure dimond burs (Meisinger, Germany) by renewing the burs in every five cavities by a single operator (dental specialist). The overall dimensions of the cavities were standardized as follows: 4 mm buccolingual width, 4 mm occlusogingival height, and 3mm gingival wall. No bevel was applied to the cavity edges. The class II box cavities were randomly divided into 2 groups.

Group 1 was restored by a specialist and Group 2 by an undergraduate student. Each operator restored the mesial of the tooth with the bulk technique using bulk-fill composite resin (Tetric-N-Ceram-Bulk) (Group 1A- Group 2A) and the distal with the oblique incremental layering technique using micro-hybrid composite resin (Filtek Z250, 3M ESPE) (Group 1B- Group 2B).

The samples were divided into 4 subgroups (n:10).

Group 1A: Dental specialist-bulk-fill composite resin

Group 2A: Undergraduate student-bulk-fill composite resin

Group 1B: Dental specialist-micro-hybrid composite resin

Group 2B: Undergraduate student-micro-hybrid composite resin

Prime&Bond NT, which is a two-stage total-etch system, was used as an adhesive in all restorations in accordance with the manufacturer's instructions. The restorations were polymerized with a 1200 mW/cm2 LED (Elipar S10, 3M ESPE, Germany). In the restorations made with the incremental technique, the micro-hybrid composite resin (Filtek Z250, 3M ESPE) was applied in 2 mm layers and the restoration was completed. Each layer was light cured for 20 seconds. In the restorations made with the bulk technique, the bulk-fill composite resin (Tetric-N-Ceram-Bulk) was placed in the cavity in a single layer of 4 mm (Table 1). Restorations were light-cured on the occlusal surface for 20 seconds, and after the band was removed, they were light-cured for 20 seconds each on the buccal and lingual surfaces. Afterwards, polishing and finishing processes were completed using Yellow extra fine finishing bur (Meisinger, Germany), aluminum oxide polishing disk (Soflex 3M ESPE,USA) Soflex polishing disc, composite polishing rubber (Hi-Shine,Polydentia, Switzerland) Polydentia composite polishing rubber.

After the restorations were completed, the apical parts of the teeth were covered with wax dental wax (Integra, Bg dental, Turkey) to prevent dye leakage from the apex and kept in distilled water for 24 hours.

Table 1. The Properties of the Composite Resins and Adhesive Agent Used.

Material	Lot numbers	Composition	Manufacturer
Tetric N-Ceram/Hybrid Bulk-fill RC	W42311	Barium glass, Prepolymer, Ytterbium trifluoride, Mixed oxide Bis-GMA, DMA	Ivoclar Vivadent, AG, Schaan, Lichtenstein, GERMANY
Filtek Z250/ Micro-hybrid RC	N946524	Zirconia/Silica Withoutsilane Treatment,Bis-GMA,UDMA,Bis EMA	3M ESPE, St Paul, MN, USA
Etching gel	181187	37%phosphoric acid	SDI,Victoris,Australia
Prime&Bond NT Adhesive Agent	052044	UDMA, PENTA Di- ve tri-metakrilat Di- and tri-methacrylate	Dentsply International, DE, USA

Table 2. Dye Penetration Scale

Score	Dye penetration level for microleakage in the occlusal wall	Dye penetration level for microleakage in the gingival wall
0	No dye penetration	No dye penetration
1	Dye penetration up to 1/2 of the occlusal wall	Dye penetration up to 1/2 of the gingival wall
2	Dye penetration exceeding 1/2 of the occlusal wall	Dye penetration exceeding 1/2 of the gingival wall
3	Dye penetration up to the pulp	Dye penetration up to the pulp

3 cm high, 2.5 cm inner diameter PVC molds were prepared in order to fix the samples to the chewing simulator. The teeth were positioned in the center of the molds by means of chemically cured cold acrylic (Imident, Imicry, Turkey).

The samples were subjected to thermo-mechanical fatigue testing with a chewing simulator (Esetron, Turkiye). A force of 50 N with 240,000 cycles, was applied in a frequency range of 1.6 Hz, simultaneously with 2500 heat cycles at temperatures of +5°C and +55°C, with the samples remaining for 60 seconds at each temperature. Then, all surfaces of the teeth except the restorations and 1 mm circumference were painted with two layers of nail varnish and kept in 0.5% basic fuchsin solution for 24 hours.

Samples were washed under running water. The restorations were divided into two equal parts in the mesiodistal direction with a low-speed precision cutting device (Esetron, Turkiye) under water cooling. The obtained sections were evaluated with a stereo microscope (Carl Zeiss, Munich, Germany) at x40 magnification according to the dye penetration scale (Table 2). Photographs were taken from each section.

The obtained data were evaluated with the IBM SPSS (VER 20.0) program. The microleakage values did not show normal distrubution according to Shapiro Wilks test. Therefore, a non-parametric test, Kruskal Wallis ANOVA post hoc Tamhane, was performed among groups for multiple comparisons The difference between the restorative materials used and the different operators was evaluated with the Mann-Whitney *U* Test. The gingival and occlusal microleakage scores of the restorative materials used were evaluated with the Wilcoxon signed ranks test. The results for all data were analysed at a significant level of $p<0.05$.

Results

The distribution of occlusal and gingival microleakage scores obtained after the microleakage test of the restorations is shown in Table 3.

According to the data obtained in our study, when only the restorative materials used in restorations were evaluated without considering the operator, no statistically significant difference was found between them ($p>0.05$).

When only the operators were evaluated without considering the restorative materials used, no statistically significant difference was found between them ($p>0.05$).

There was a statistically significant difference between the occlusal and gingival microleakage scores in Group 2A ($p<0.05$). More microleakage was observed in the gingival region than in the occlusal region. There was no statistically significant difference between the occlusal and gingival values of Group 1A, Group 2B, and Group 1B ($p>0.05$).

Table 3. Microleakage Scores of the Occlusal and Gingival Margins

Group		Score 0	Score 1	Score 2	Score 3	Median (min-max)
Group 1A	Occlusal	10	0	0	0	0-0
	Gingival	5	5	0	0	0-1
Group 1B	Occlusal	10	0	0	0	0-0
	Gingival	8	2	0	0	0-1
Group 2A	Occlusal	10	0	0	0	0-0
	Gingival	1	9	0	0	0-1
Group 2B	Occlusal	10	0	0	0	0-0
	Gingival	5	5	0	0	0-1

Discussion

One of the main purposes of dental restorations is to cover the exposed dentin and to protect the pulp from external factors. Ensuring an adequate seal between the tooth and the restoration is very important for the success and the longevity of the restorations.

There are many application steps such as adhesive, composite resin and light application processes where mistakes can be made in the construction of restorations. In these processes usage limitations and correct use are as important as the properties of the material used. Therefore, the final result depends not only on the material but also on the knowledge and skills of the operator about the material.

Few studies have been carried out on operator experience, and more adhesive resin applications than restorative materials have been emphasized. Therefore, in this study, the effect of bulk-fill and microhybrid composite resin materials on microleakage with a two-step total-etch adhesive was evaluated.

According to the data of our study, the H0 hypothesis was accepted.

Although the number of samples in the groups varies in microleakage studies, it has been reported that the number of samples for each group should be 2-12 in many studies. In our study, each group consisted of 10 class II box cavities.[4,5]

It has been reported by many studies that the time elapsed after tooth extraction and the storage conditions will affect the experimental results. The most commonly used solutions are %10 formail-acetate, chloramine and %0,05-%0,1 thymol.[6-10] Considering the results of the studies of Goodis *et al.*, the teeth were stored in a glass jar filled with 0.1% thymol at +4 ^{o}C in order to preserve the permeability of the dentin.[11,12]

Many methods such as dye penetration, indicators, radioactive isotopes, microbial permeability, scanning electron microscopy (SEM), artificial caries techniques, and electrical current are used to evaluate the edge sealing of composite restorations. In this study we preferred the dye penetration method, which is the most preferred method among these methods because it is cheap and practical[13], 0.5% basic fuchsin solution we applied as a dye for 24 hours.

Cavity size, shape, and localization influence the results of microleakage studies. Therefore, all cavities in this study were prepared by a single operator in the same size, shape, and localization (Standard Class II box cavity on the mesial and distal surfaces of the teeth, 1 mm above the CEJ, 4 mm buccolingual dimension, 4 mm occlusogingival dimension, 3 mm gingival floor width pulp depth). A beveled margin was not applied to the box cavities, as the composite on the beveled occlusal margins could break under chewing forces due to insufficient thickness.[8,14]

The structure of the tooth used in the studies plays an important role in the data obtained. For this reason, in this study, the mesial side of the same tooth was restored with bulk-fill composite resin and the distal side with micro-hybrid composite resin in order to eliminate the tooth-related variable.

In our study, thermo-mechanical aging was performed by using a chewing simulator in order to provide behaviors similar to the oral environment in *in vitro* conditions and to predict clinical performances. Jung et al and Shahidi et al showed that the microleakage values of composite restorations increased after thermo-mechanical aging in their studies.[15,16]

In this study, a chewing load of 50 N at a frequency of 1.6 Hz was applied for 240,000 cycles to imitate the 1-year aging process. Simultaneously, all teeth were immersed alternately in water baths at the temperature of 5°C (±5°C) and 55°C (±5°C) with a dwell time of 30 seconds in each bath for 2500 cycles.

The total-etch adhesive system is considered to be critical and highly technically sensitive because of including etching, washing and drying steps.[17,18] Acetone-based total-etch systems are more technically sensitive than water and ethanol-based total-etch systems.[19,20] Many researchers evaluated the relationship between operator experience and the success of adhesive systems, and have obtained different results.

In the microleakage study of Giachetti *et al.*, in which they evaluated the operator's skill in restorations using self-etch and total-etch adhesive systems, no difference was found between the student and specialist groups in the self-etch system, whereas specialist group was found to be more successful in the total-etch system.[21]

In their study, Gueders and Geerts reported that when dentists and undergraduate students applied three-step total-etch adhesive system, two-step total-etch system and two-step self-etch adhesive system the microleakakage scores were lower in dentists.[22]

In the study by Karaman *et al.*, in which they evaluated both the effect of total and self-etch systems with operator variability on microleakage, dental specialist and undergraduate students had similar results in total-etch systems and showed little sensitivity to operator skill, while dental specialists were found to be more successful in self-etch adhesives.[23]

Adebayo *et al.* reported that the operator's ability to use material can improve with repeated use of the material.[24]

Miyazaki *et al.* reported in their study that inexperienced operators tend to read and apply the application instructions more carefully, and that technical sensitivity is the main factor in dentin bonding.[25]

When the occlusal and gingival microleakage scores of the operators who applied the restorations were evaluated without considering the restorative materials used in our study, there was no statistical difference between them.

In this study, in addition to the effect of operators on the adhesive system, also their effect on the adhesive-composite resin association was evaluated.

While the total-etch adhesive system and hybrid composite resin are routinely used in dentistry faculty clinics, the bulk-fill composite resin is not routinely used. We think that the reason why there is no difference between the operators, the students tend to carefully read the instructions of the materials used for the first time and apply the materials carefully.

Kader *et al.* evaluated the microleakage of Class II cavities by restoring the micro-hybrid composite resin with the incremental technique and the Bulk-fill composite resin with the bulk technique. They reported that although less microleakage was observed in the restorations made with the layering method, there was no statistically significant difference between the groups.[2]

In the study of Behery *et al.*, in which they evaluated the microleakage in the gingival area in Class 2 cavities, no significant difference was found between bulk-fill and conventional composite resin in terms of microleakage.[26]

Mosharrafian *et al.* reported that there was no significant difference between the restoration techniques in the gingival or occlusal regions in their microleakage study, in which they applied two different bulk fill composite resins in Class II cavities with the bulk technique and the traditional micro-hybrid composite resin with the incremental technique. However, in all three groups, it was reported that the microleakage in the gingival region was significantly higher than the microleakage in the occlusal region.[27]

Garcia Mari *et al.* found no significant difference between bulk fill and conventional composite resin in their microleakage study, in which they restored class II cavities prepared above the CEJ with bulk-fill composite resin using the bulk technique and a conventional composite resin using the incremental technique.[28]

In Razieh *et al.*'s study evaluating the microleakage of bulk-fill composites and conventional composites, no significant difference was found in gingival microleakage scores.[29]

Miletic et al, stated in their studies that there was more microleakage in the gingival in conventional composite resins than in bulk-fill composite resins.[5]

When the restorative materials used in this study were evaluated without considering the operator, no statistically significant difference was observed between the occlusal and gingival microleakage scores. Our results were consistent with the results obtained by Kader *et al.*, Mosharrafian *et al.*, and Garcia Mari *et al.* The reason why our study is not compatible with the results of Miletic *et al.*, may be due to the fact that the prepared cavities were 1 mm above the CEJ.

When evaluated within the group, no statistically significant difference was found between the occlusal and gingival microleakage scores of Groups 1A, 1B, and 2B, but in Group 2A was observed significantly more gingival microleakage than occlusal. Restoration procedures in the gingival region are more difficult than in the occlusal region. Since the student's ability to use the material develops due to the repetitive use of materials, we think that the reason for the difference in Group 2A is the use of a new material that the student does not routinely use in this region, although there is no difference with the material used routinely in gingival region.

Within the limits of this study, it showed that microleakage is more dependent on the interaction between the operator and the operator/material rather than the material chosen.

There main limitation is the *in vitro* design of the study. Ideally, microleakage should be tested with variables such as chewing forces, food types, mouth temperature, humidity, enzymes, bacterial products, and the presence of saliva. Testing with these variables as well as subjecting samples to thermo-mechanical aging to imitate intraoral conditions is also recommended for future research. However, more clinical studies should be done on this subject to confirm the clinical validity of the results obtained in the study.

Also, there was only one operator in each group and this operator may be experienced or inexperienced.

Conclusions

1. When all microleakage values were compared, no difference was found between the dental specialist and the undergraduate student.
2. When all microleakage values were compared, no statistically significant difference was found between bulk-fill composite resin (Tetric N Ceram Bulk fill) and micro-hybrid composite resin (Z250).

While there was a significant difference between the occlusal and gingival microleakage scores in the group in which the bulk-fill composite resin was applied by the undergraduate student, more gingival microleakage was detected. This indicated that microleakage was more dependent on the interaction between the operator and the operator/material rather than the material chosen.

Conflicts of Interest

There is no conflict of interest.

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